ATMOSPHERIC SCIENCE

Bigger, Badder Bolts

Lightning reveals its secrets only to the most painstaking analyses.

One-point-twenty-one gigawatts of 1980s film fame notwithstanding, the firmly established science of lightning is shockingly sparse. While the electrical arc itself is basically understood, the spark necessary to initiate it remains an area of speculation and active research (see "Out of Thin Air" in the March 2018 issue of *1663*). Just as puzzling is the fact that some intra-cloud bolts of lightning appear to be hundreds of times larger and more powerful than all the rest.

Los Alamos scientist Michael Peterson seeks out these "superbolts" and other novel lightning events by digging into colossal Earth-observation datasets from the National Oceanic and Atmospheric Administration's GOES-16 and GOES-17 weather satellites and the joint Los Alamos–Sandia national laboratories' FORTE nuclear-detonation detection and lightning-observing satellite. But unlike initial analyses of these satellites' data, which were optimized for rapid processing in order to provide real-time hazard warnings (GOES-16 and -17) or for recording single quick events (FORTE), Peterson developed a new algorithm to assemble a more complete picture of lightning in the historical data. In data from 2018 alone, his algorithm caught more than 14 million lightning events that had been underrepresented by the real-time data processing and were therefore widely ignored by the scientific community.

What Peterson found was downright astonishing. He discovered a population of flashes that streak horizontally over hundreds of kilometers. The longest of these was 673 kilometers, roughly the width of Kansas, while another spiderweb-like flash covered an area the size of Ohio.

Importantly, Peterson's observations of extreme lightning offer new insights into an old controversy, set off by a 1977 analysis of data from the Los Alamos Vela nuclear-detonation detection satellites. For decades, atmospheric scientists have argued about whether superbolts—defined as having 100 or more times the power of "normal" gigawatt lightning—are unique phenomena with their own distinct physics or simply the upper end of the distribution of normal lightning observations. The latter is a real possibility because the observed flash intensity depends greatly on the conditions under which it is viewed. For example, some clouds reflect additional light back to the camera, brightening the observed flash, while other dense clouds can get in the way and obscure the flash.

Peterson analyzed his data and found two scenarios that accounted for most of the observed superbolts. One of these involved the thunderstorm's "anvil" clouds. Around the edge of the storm, he reasoned, anvil clouds would present favorable viewing conditions, with reflecting layers that redirect light to the satellite. This would explain earlier findings that ordinary lightning with relatively weak electrical currents can still produce superbolt-class emissions and that the FORTE superbolts were less obscured by clouds than usual.

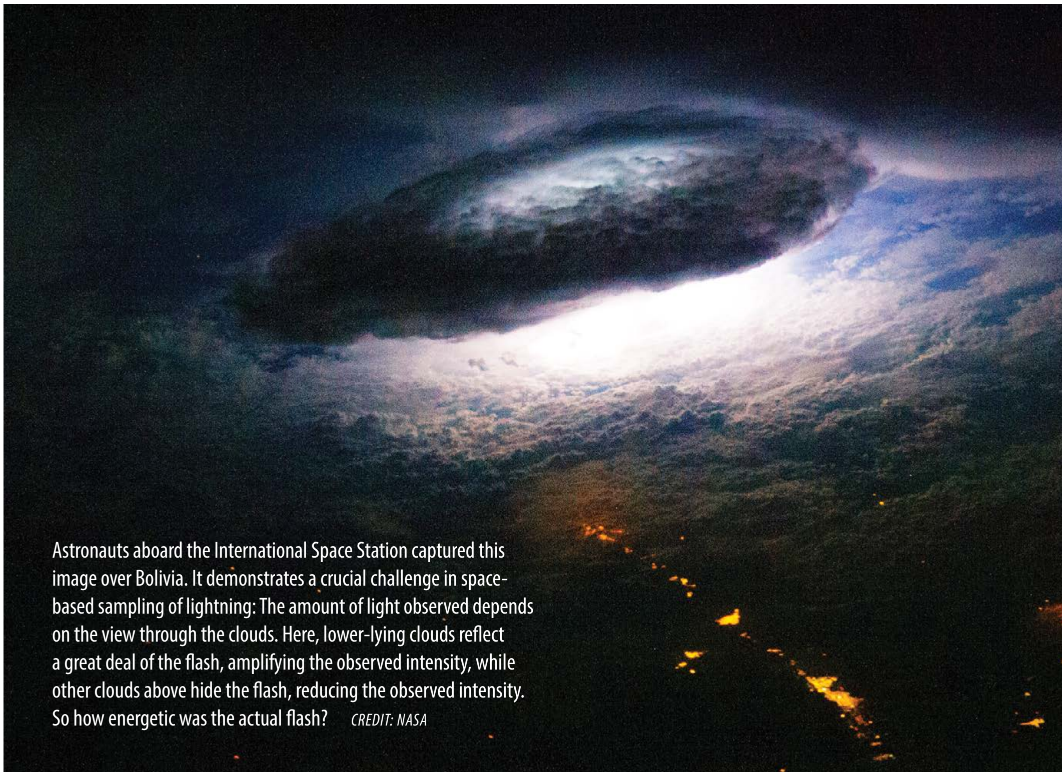
But the other population of superbolts was buried inside the expansive "stratiform" rainclouds that form adjacent to severe thunderstorms and are responsible for the long periods of light rainfall that linger after the storm passes. Stratiform clouds are arranged in uniform layers that enable unique lightning physics, and the most extreme cases Peterson identified were all examples of stratiform lightning.

So which is it? Unique hundred-gigawatt physics or just favorable viewing conditions?

"The simplest explanation would be one or the other," Peterson says. "But looking at the data, I'd have to say that it appears to be both. Some anvil superbolts aren't all that super, but the stratiform superbolts certainly appear to be. Their exceptional brightness is just another way in which stratiform lightning is unique. We still have much to learn about the physics that allows these beasts to be so powerful."

One-*hundred*-twenty-one gigawatts of power, at least.

—Craig Tyler



Astronauts aboard the International Space Station captured this image over Bolivia. It demonstrates a crucial challenge in space-based sampling of lightning: The amount of light observed depends on the view through the clouds. Here, lower-lying clouds reflect a great deal of the flash, amplifying the observed intensity, while other clouds above hide the flash, reducing the observed intensity. So how energetic was the actual flash? *CREDIT: NASA*